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# **EUROPEAN PATENT APPLICATION**

⑲ Application number: 89630141.3

⑥ Int. Cl.<sup>5</sup>: **A 46 D 3/05**

**F 16 J 15/32, A 46 B 3/06**

⑳ Date of filing: 30.08.89

③ Priority: 30.08.88 US 238082

④ Date of publication of application:  
07.03.90 Bulletin 90/10

⑧ Designated Contracting States: DE FR GB

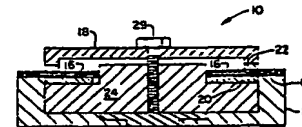
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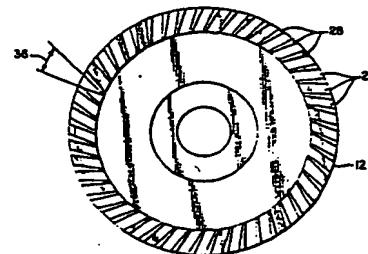
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## ⑤ Method and apparatus for manufacturing compliant brush seals.

⑤ A method and fixture (10) for assembling compliant seals includes an aligning member (12) having a grooved surface for receiving a plurality of loose bristle elements (16). The bristle elements (16) are received within the grooves (26) and aligned thereby. First and second backing rings (20,22) sandwich the aligned bristles (16) and are clamped by first and second clamping members (18, 24). The clamped rings (20,22) and bristle elements (16) are then removed from the aligning member (12) and permanently secured together, forming the finished seal.



**FIG. 1**



**FIG. 2**

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## Description

## METHOD AND APPARATUS FOR MANUFACTURING COMPLIANT BRUSH SEALS

## FIELD OF THE INVENTION

The present invention relates to a method and an apparatus useful in assembling compliant brush seals.

## BACKGROUND

Compliant seals for preventing gas leakage between a stationary housing and a rotating shaft passing therethrough are well known. Such seals include a plurality of individual bristles consisting of metallic wire or other fiber, extending from a backing member into contact with the rotating shaft. The ends of the bristles brush lightly against the rotating shaft, hence such seals may also be termed "brush seals".

The packed bristles of the seal discourage gas flow between the stationary housing and the shaft, while the contact of the bristles with the shaft establishes a "zero clearance" between the seal and shaft further enhancing the seal effectiveness.

Such seals include inherent advantages in terms of resistance to high temperatures and the ability to accommodate radial runout of the shaft, as well as reduced component cost as compared to known labyrinth or knife edge seals used in gas turbine engines.

As has long been appreciated by those familiar with such sealing elements, it is necessary to pack the individual bristles uniformly about the circumference of an annular seal as well as to align each bristle element properly so as to achieve the desired advantages. It is easily apparent that even a slight deficiency in the arrangement of the bristles about the backing ring can give rise to a leakage path which could compromise the brush seal effectiveness.

Present methods of manufacturing brush seals preassemble a quantity of individual bristles into a quantity of small bundles which are arranged and temporarily secured at the desired alignment. The backing member is fabricated from two annular rings which are disposed on opposite sides of the assembled bristle bundles with the bristles and annular backing rings being permanently secured, thus forming the completed seal.

One such method, disclosed in U.S. Reissue Patent 30,206, provides an annular holding ring having a plurality of radial holes disposed therein. Bundles of individual bristles are drawn radially into the holes and secured by a wire loop pulled manually through the holding ring outer periphery. After drawing all the individual bristle bundles into the holding ring, first and second annular backing rings are fused to the bristles and the brush seal separated from the holding ring by cutting or otherwise machining away the excess bristle material. The remainder of the individual bristle bundles must then be removed from the holding ring and the process repeated for the next seal.

Another prior art method, disclosed in U.S. Patent

4,274,575, preassembles individual bristle bundles into short cylindrical tubes, arranging a plurality of such tubes about an annular holding member in the desired orientation. The small tubes may be secured by adhesive or some other convenient scheme. The annular backing rings are again placed adjacent the protruding bristles and fused or otherwise permanently secured to form the brush seal.

Such preassembly methods require additional steps to temporarily secure the individual bristle bundles prior to positioning and permanently securing the annular backing rings. Additionally, the use of discrete bundles of bristles can result in a nonuniformity of the bristle density in the circumferential direction. Further, and in particular with respect to the holding member having a plurality of radial passages disposed therein, repeated use of the holding member results in wearing of the passages and the possibility of the occurrence of misalignment of individual bristles.

What is needed is a simple, effective method for temporarily positioning, aligning, and restraining individual bristles prior to permanently securing the bristles to the backing members.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and means for holding, aligning, and positioning a plurality of individual bristle elements preparatory to securing the bristle elements to a backing ring thereby forming a completed brush seal.

It is further an object of the present invention to provide a method and means for holding bristle elements which is particularly well adapted for use with automatic machinery.

According to the present invention, an aligning member is provided which includes a surface having a plurality of grooves disposed therein. The bristle elements are received in and correctly aligned by the grooves extending from at least one groove end.

The portion of the bristle elements extending from the groove is sandwiched between two backing members which are clamped securely between two releasable holding members. The backing members and bristle elements are removed from the grooved aligning member which is ready for immediate re-use.

The brush seal is completed by removing any excess bristle material and by permanently securing the bristle elements to the backing rings. The holding members are ready for immediate reuse in assembling subsequent brush seals.

Unlike prior art seal assembly methods and fixtures, the means and method according to the present invention is particularly well adapted for automatic execution. By positioning the grooved aligning member in conjunction with a bristle dispensing device capable of delivering preset quantities of uniformly cut bristles, the grooved aligning member may be rotationally indexed as

each groove receives the proper size and number of bristles. The clamping of the aligned bristles between the holding members against the backing member(s), either comprising a single annular member or a pair of annular members sandwiching the bristles therebetween, to be removed from the aligning member and machined, welded or otherwise worked without disturbing the desired alignment. The backing rings and bristles are permanently secured by any of a variety of known methods such as welding, soldering, bonding, etc.

Both these and other objects and advantages of the seal assembly method and apparatus of the present invention will be apparent to those skilled in the art upon review of the following specification and the appended claims and drawing figures.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a cross section of the assembly apparatus according to the present invention.

Figure 2 shows a view of the grooved aligning member as indicated in Figure 1.

Figure 3 shows a perspective detail of the grooved surface of the aligning member.

Figure 4 shows a completed brush seal disposed about a rotating shaft.

Figure 5 shows the assembly fixture according to the present invention arranged for automatic manufacture.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing figures, and in particular to Figure 1 thereof, an apparatus according to the present invention will be described in detail. Figure 1 shows a fixture arrangement 10 according to the present invention. The fixture 10 includes an annular aligning member 12 having an annular surface 14 which is adapted, as discussed hereinbelow, to receive and align a plurality of separate bristle members 16.

The fixture also includes a first removable holding member 24 disposed, in the preferred embodiment, within the annular aligning member 12. The holding member 24 supports a first backing ring 20 adjacent the portion of the bristle elements 16 extending beyond the surface 14. A second backing ring 22 is positioned opposite the first backing ring 20, sandwiching the bristle elements 16 therebetween.

A second holding member 18 is provided behind the second backing ring 22. The holding members 18, 24 are forced together by urging means, such as a threaded bolt 29, securely but releasably clamping the backing rings 20, 22 and bristle elements 16. The sub-assembly of holding members 18, 24, bristle elements 16, and backing rings 20, 22 is removed from the aligning member 12. The bristle elements 16 remain in the desired alignment and the aligning member 12 is ready for reuse.

The clamped bristles 16 and backing rings 20, 22 are then fused or otherwise permanently secured together forming a brush seal 30 which is ultimately used for sealing between a static housing (not

shown) and a rotating shaft 33 as shown in Figure 4. The step of permanently securing the bristles 16 to the backing rings 20, 22 includes, for example, welding or fusing the bristles and backing rings together and subsequently trimming excess bristle material radially outward of the fusing weld 34.

Figure 2 shows a top view of the aligning member 12 giving a more detailed view of the clamping surface 14. Grooves 26 are disposed in the surface 14, and are angularly skewed by an angle 36 with respect to the radius of the annular surface. The angle 36 varies according to the diameter, resiliency of the bristle material, speed of rotation of the shaft, etc. but is, for most applications, approximately 45°. Raised land portions 28 separate the grooves 26 and assist the alignment of the individual bristle members 16 in the equally spaced grooves 26. Figure 3 shows a view of the grooves 26 and lands 28 as indicated in Figure 2.

Figure 5 shows one method of automating the assembly procedure according to the present invention wherein a bristle element dispenser 38 delivers a preselected number of individual bristles 16 to each groove 26 in the first member 12. The member 12 is indexed rotationally 46 relative to the bristle dispenser 38 until each groove 26 has been filled with a preselected quantity of bristle elements 16. The second clamping member 18 (not shown in Figure 5) as well as the second backing ring 22 are then positioned with respect to the fixture 10 and the bristles 16 and backing members 20, 22 temporarily clamped between the holding members 24, 18 by engaging the bolt 29.

The clamped subassembly 16, 20, 22, 18, 24, 29 is then removed and the rings 20, 22 and bristles 16 permanently secured together. The holding members 18, 24 are released and immediately reused. Additional sets of holding members 18, 24 may be provided to speed up the entire process.

As will now be apparent to those skilled in the art, the method and fixture according to the present invention has several advantageous features not known or achieved in prior art methods of compliant seal manufacture. These advantages include the simplicity of the individual fixture components, with the reusable aligning member 12 being the most complicated. Also, by clamping the backing members 20, 22 and bristle elements 16 securely between the holding members 18, 24, the risk of deformation or damage to the completed seal 30 is reduced during the subsequent handling and trimming operation. It will further be apparent that the individual fixture components do not experience sliding or other wear-inducing contact with the bristles, thereby lengthening the service life of the fixture.

The fixture and method according to the present invention are thus well adapted for achieving the objects and advantages as set forth hereinabove, and it will further be apparent to those skilled in the art that other equivalent configurations and methods may be made and practiced without departing from the scope of the invention which is limited only by the claims as set forth hereinbelow.

## Claims

1. A method of manufacturing a compliant seal having a plurality of bristle elements secured to an annular backing member and extending radially into contact with a rotating shaft, comprising the steps of:  
 providing a first annular aligning member having an annular flat surface, the surface having a plurality of generally radially extending grooves disposed therein, said grooves being evenly distributed about the circumference of the surface,  
 placing a predetermined plurality of bristle elements within each groove, the bristle elements extending generally radially from the corresponding groove and being aligned therewith,  
 sandwiching a portion of the bristle elements extending from the grooves between first and second annular backing rings,  
 releasably securing the placed bristle elements between the annular backing rings by clamping the rings between first and second holding members,  
 permanently securing said bristle elements to said backing plates, and  
 releasing the backing rings and bristle elements from the first and second holding members.

2. The method as recited in Claim 1, further comprising the step of:  
 trimming excess bristle length following the step of permanently securing the bristle elements to the backing rings.

3. The method as recited in Claim 2, further comprising the steps of:  
 rotating the aligning member relative to a bristle dispenser,  
 indexing said rotation relative to the number of grooves in the aligning member surface, and  
 dispensing a predetermined number of bristle elements into each groove in sequence.

4. A method of aligning and holding a plurality of bristle elements preparatory to permanently securing the aligned elements to a separate backing member, comprising the steps of:  
 providing an aligning member having a flat surface including a plurality of grooves disposed therein, said grooves being oriented coincident with a desired alignment of the bristle elements,  
 placing a preselected plurality of bristle elements into each groove, the bristle elements projecting from one end of the groove and being aligned thereby,  
 clamping said bristle elements between a first holding member and a second holding member, and  
 permanently securing a portion of each of the aligned bristle elements projecting from the groove to a backing member.

5. The method as recited in Claim 4 wherein the aligning member, holding members and

backing member are all annular and further comprising the steps of:  
 aligning said grooves tangent to a concentric circle disposed radially inward of the holding member.

6. The method as recited in Claim 5 wherein the placing step includes the steps of  
 rotationally indexing the aligning member relative to a bristle dispenser, and  
 operating said bristle dispenser to place the preselected number of bristle elements into each groove as each groove is individually indexed into position.

7. A fixture for assembling a compliant seal, comprising:  
 an annular aligning member including means for receiving and aligning a plurality of bristle elements,  
 a first, lower holding ring disposed concentrically within the aligning member,  
 a second, upper holding ring,  
 first and second seal backing rings, disposed adjacent to the bristle members and concentrically within the aligning ring, the backing rings sandwiching the bristle elements therebetween,  
 the first and second holding rings sandwiching the first and second backing rings therebetween, and  
 means for releasably urging the first and second holding members together, thereby releasably clamping the bristle elements between the first and second backing rings.

8. The fixture as recited in Claim 7, wherein the means for receiving and aligning the plurality of bristle elements includes  
 a plurality of grooves disposed in an annular surface of the aligning member, the grooves extending generally radially with respect to the member and adapted to receive a quantity of bristles therein.

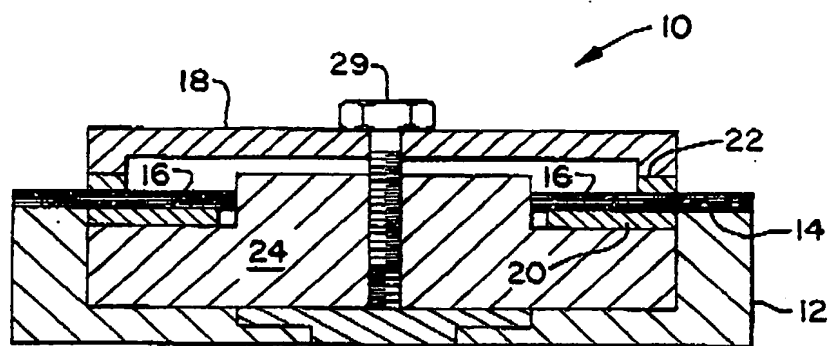


FIG. 1

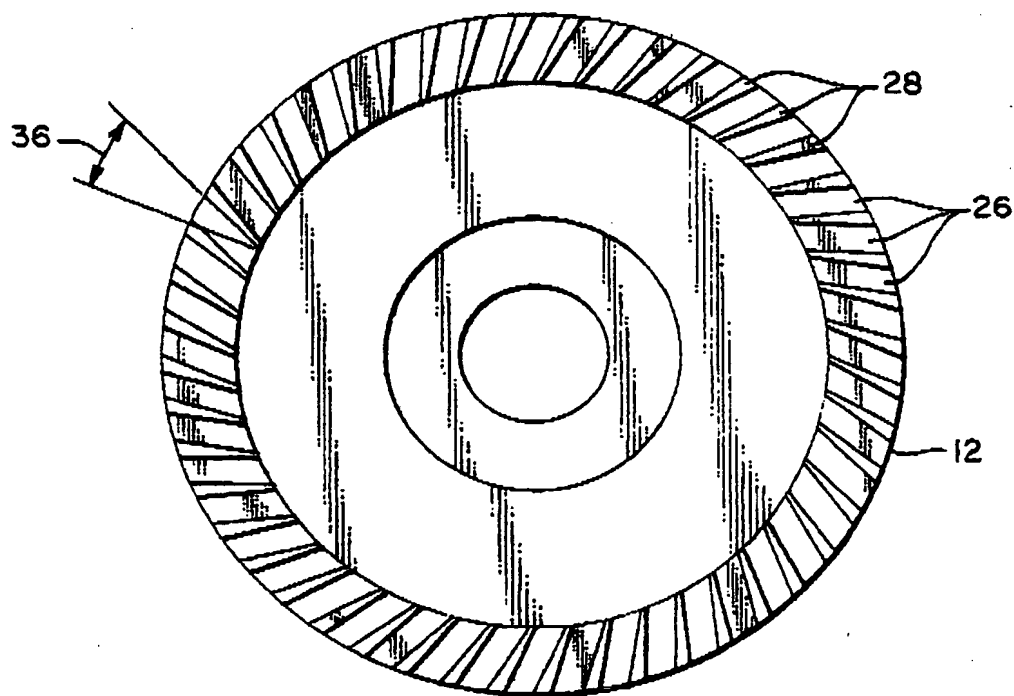


FIG. 2

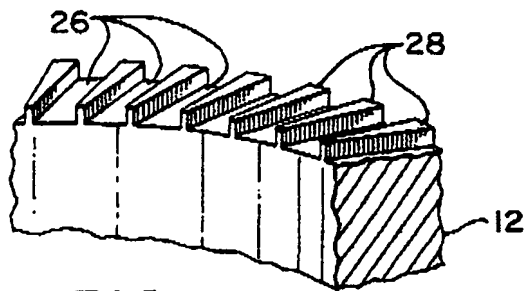


FIG. 3

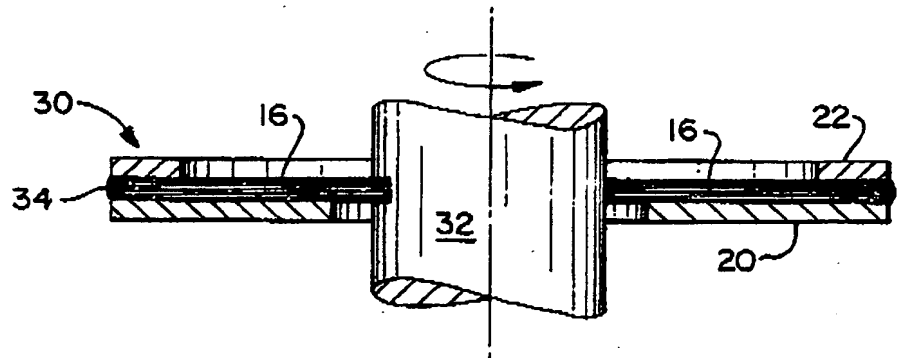


FIG. 4

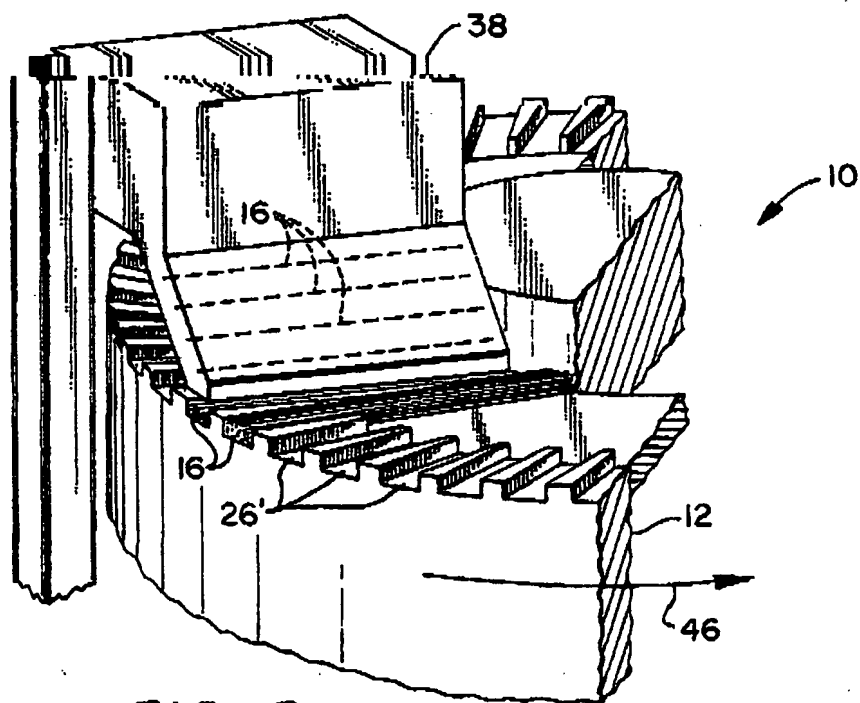


FIG. 5



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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0192476 (ROLLS-ROYCE PLC) * claims 25-27; figures 1-11 * ---	1, 4, 7	A46D3/05 F16J15/32 A46B3/06
A	DE-A-2830839 (ROLLS-ROYCE LTD) * claims 1-6; figures 1-4 * -----	1, 4, 7	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			A46D A46B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 06 DECEMBER 1989	Examiner ERNST R.T.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			

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